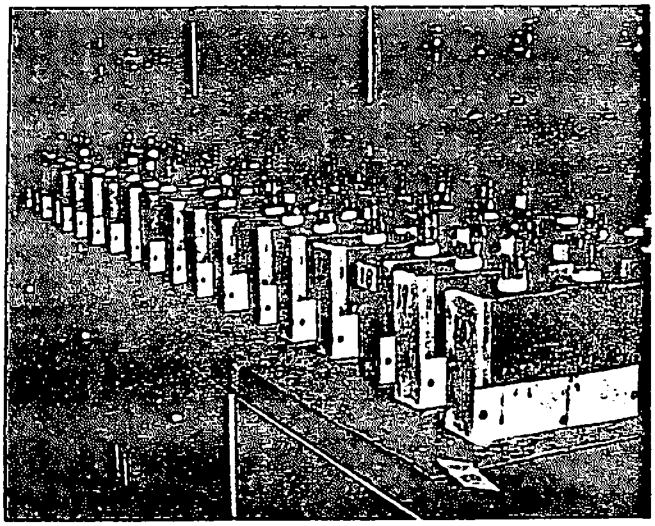

Fig. 1. Newly-emerged bees were placed in the small laboratory cages, and the herbicides were fed to the bees in sugar syrup.

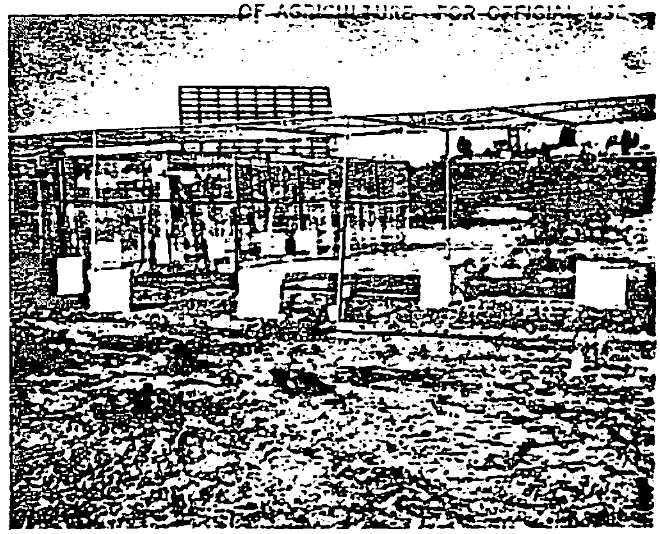

Fig. 2. These colonies were placed in Saran® screen cages and fed 2 levels of picloram to determine the effect on brood rearing.

How Herbicides Affect Honey Bees[1,2]

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ALTHOUGH most herbicides are considered non-toxic to honey bees, *Apis mellifera* L., beekeepers continue to report losses of bees from the use of herbicides. Therefore, studies were made between 1969 and 1974 to determine how herbicides applied at various rates and by various methods, except dusting, affected honey bees.

We excluded dusting as a method of application because most herbicides are applied as sprays and also because Atkins and Anderson[1-6] included most herbicides in their monumental and comprehensive studies on the effect of dusting pesticides on honey bees. The laboratory studies were conducted at the Bee Research Laboratory at Tucson and the field tests within 75 miles of Tucson.

Feeding Adult Bees in Cages

Thirty-one formulations of herbicides in concentrations of 10, 100, and 1,000 ppm (parts per million by weight) were fed in sugar syrup to newly-emerged bees in small cages (Fig. 1). Six herbicides, paraquat, MAA, MSMA, DSMA, hexaflurate, and cacodylic acid were highly toxic to the bees at concentrations of 100 and 1,000 ppm.[11] Bromoxynil and endothall were highly toxic at 1,000 but not at 100 ppm. Relatively non-toxic herbicides were 2,4-D, 2,4,5-T, silvex, dicamba, 2,3,6-TBA, chloramben, picloram, ethephon (2-chloroethylphosphonic acid), EPTC, and dalapon. No significant differences were found in the toxicity between purified and commercially formulated herbicides.

Effects on Brood-rearing

Ten herbicides were fed in sugar syrup.[10] Picloram, 2,3,6-TBA, and dicamba had no adverse effects on brood production when fed at 1,000 ppm (Fig. 2). Chloramben and dalapon reduced brood rearing 25 and 50 per cent, respectively, when fed at the same concentration. EPTC, 2,4-D, 2,4,5-T, silvex, and 2,4-DB fed at 1,000 ppm either halted or severely reduced brood to only 0 to 20 per cent of the check colonies.

When the phenoxy herbicides (2,4-D, 2,4,5-T, and related compounds) were fed at 500 ppm, they completely stopped brood rearing. Eggs did not hatch, even though the queens usually laid large numbers of eggs. Feeding at 100 ppm caused a marked reduction in brood rearing. The bees in these colonies were also unable to rear eggs or young larvae given them from normal colonies. The effects were temporary because soon after feeding of the phenoxys was stopped, brood rearing returned to normal in the experimental colonies.

Similar results were obtained when the phenoxys were placed in the water supply of colonies, if no other water was readily available. However, the bees virtually ignored the phenoxy-contaminated water when they had a free choice between it and uncontaminated water. They may have preferred uncontaminated water because the surfactant in the herbicide was repellent.

Paraquat fed to colonies in either water or syrup killed the colonies and its effect on brood rearing could not be determined.

Sprays Applied to Caged Bees

Twenty-four different combinations of herbicides, carriers, and formulations were sprayed over honey bees in small laboratory cages at the rate of four pounds of active ingredient per acre (Fig. 3). Paraquat, MSMA, and cacodylic acid were highly toxic when applied in this manner. Two carriers, diesel oil and a phytobland oil (Mobilsol 100), caused heavy mortality the day of application, but very little on succeeding days.[9]

Several formulations and combinations of 2,4-D, 2,4,5-T, silvex, and picloram were non-toxic when applied with water as was a water spray containing endothall. Herbicidal sprays containing oils were toxic to bees the first day, as were the oil sprays by themselves, indicating that the oil carrier was toxic, and not the herbicide.

Surfactants Drowned Bees

Small amounts of surfactants (100 to 500 ppm) in their water supply drowned large numbers of bees when the bees had no other source of water, as in flight cages or dry field locations.[8] Drowning occurred as long as six months after the water had been contaminated with a surfactant. In extremely hot weather, the loss of water carriers by drowning caused the colonies to die within a few days. When the weather was moderately warm, the colonies lost their unsealed brood almost immediately and did not raise any more brood as long as the only available water contained a surfactant.

When bees were given free choice, most collected from uncontaminated water and did not gather the water containing surfactant (Fig. 4). When ponds were contaminated with a surfactant this repellency lasted for several months and gradually declined with time.

Airplane Spraying

When ½ lb/acre of 2,4,5-T was sprayed by airplane on a 1500-acre pasture to kill velvet mesquite, *Prosopis juliflora* var. *velutina* (Woot.) Sarg., no observable damage occurred to colonies located in the middle of the sprayed area.[7] However, the honey flow was greatly reduced.

Similarly, no damage to colonies was observed when 2,4-D was sprayed from an airplane at rate of 2.5 lb/acre to a 1500-acre mountain pasture to control pointleaf manzanita, *Arctostaphylos pungens* H.B.K.

A cotton desiccant also did not cause any measurable damage to honey bees when the colonies were moved into a 28-acre field of Pima cotton, *Gossypium hirsutum* L., before the spray was applied by air. The desiccant contained sodium chlorate, ammonium phosphate, and phosphoric acid and was applied in a water solution.

Residues of Herbicides in Bees, Honey, and Wax

Small amounts of 2,4,5-T were found in bees and honey 14 months and in wax 19 months after bees had stopped collecting water contaminated with 1,000 ppm of this herbicide.[12] This water was the only water available to colonies placed in an isolated desert location (Fig. 5), and high levels of 2,4,5-T were found in the bees during the two months they were using it. Then, once the summer rains began, the bees stopped collecting the water containing 2,4,5-T. The residue dropped rapidly in the bees and honey, but persisted at low levels for a long time. The small amount of residue found in the colonies would not appear to be a serious problem, but was of academic interest. Brood rearing which had virtually ceased, soon returned to normal when uncontaminated water became available.

Under normal circumstances, 2,4,5-T would probably never contaminate water in excess of 10 ppm (one-hundredth's the concentration fed).

Summary

Some herbicides are relatively non-toxic to honey bees and a few, such as picloram, may be beneficial. The toxicity of others ranged from slight to high depending on the herbicide.

Herbicides that were highly toxic when fed or sprayed on colonies were paraquat, MAA, MSMA, DSMA, hexaflurate, and cacodylic acid. The carriers, diesel oil and a phytobland oil, were toxic the first day they were sprayed on bees.

The phenoxys (2,4-D, 2,4,5-T, silvex, etc.) were relatively non-toxic to adult bees, but stopped brood rearing and prevented eggs from hatching when high concentrations were fed to colonies in sugar syrup or water. These effects were reversible, and colonies returned to normal soon after the feeding of the phenoxys was stopped.

Surfactants drowned larged numbers of bees for as long as six months after they were placed in a water supply. However, the surfactants were repellent, and bees did not collect surfactant-contaminated water when given a choice between it and uncontaminated water.

Residues of 2,4,5-T were found in honey, bees, and wax in small and probably unimportant amounts for more than a year after contaminated water was replaced with clean water.

Aerial spraying of 2,4-D, 2,4,5-T, and a cotton desiccant did not cause any observable loss of honey bees when colonies were in the area sprayed.

Conclusion

Under certain conditions, some herbicides as well as their carriers and/or surfactants can cause losses of honey bees. Some factors affecting losses are the herbicide used, the rate of application, the method and time of application, the sources of water available, the plants to which the herbicide was applied, and where the bees are collecting nectar, pollen, and water.

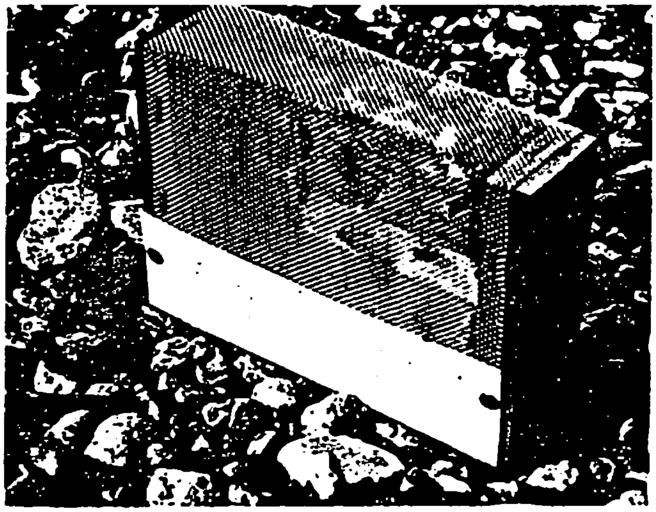

Fig. 3. Bees were captured at the entrance of the hive and placed in small cages. Then herbicides were sprayed over these cages.

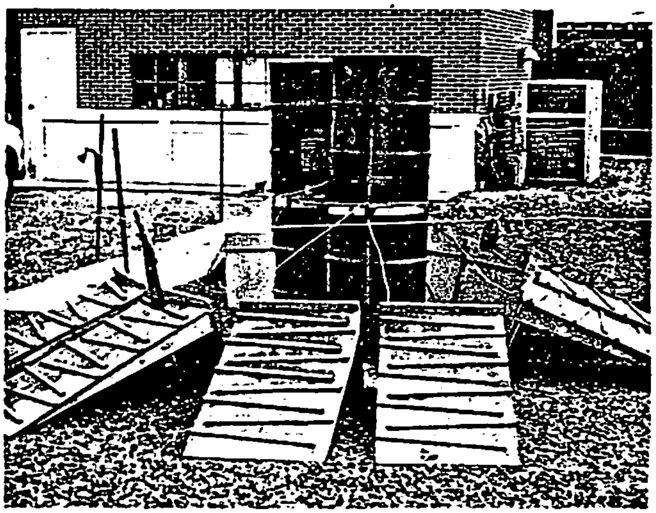

Fig. 4. When bees were given a choice between water containing surfactants and other water on drip boards, almost all the bees collected water from the non-surfactant contaminated water.

Most of the herbicides probably do not cause appreciable losses of honey bees as usually applied. High rates of applications or abnormal circumstances, for example, bees visiting water drained from a spray tank, could result in bee losses from relatively non-toxic herbicides.

The greatest danger would appear to be in the use of oils, and from high concentrations of DSMA, MSMA, paraquat, and similar chemicals which are used to kill all the vegetation which is sprayed. This is done frequently to control plants along and in irrigation ditches, and along rights-of-way for railroads and highways.

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FOOTNOTES

[1] Mention of a pesticide or a proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the USDA.

[2] Cooperative investigations of the Agricultural Research Service, USDA and the Arizona Agricultural Experiment Station, Tucson.

Fig. 5. Joseph Moffett is examining a colony placed in an isolated desert apiary on the Santa Rita Experimental Range. The water supply was contaminated with 2,4,5-T to determine how long it persists and where it can be found in a colony.

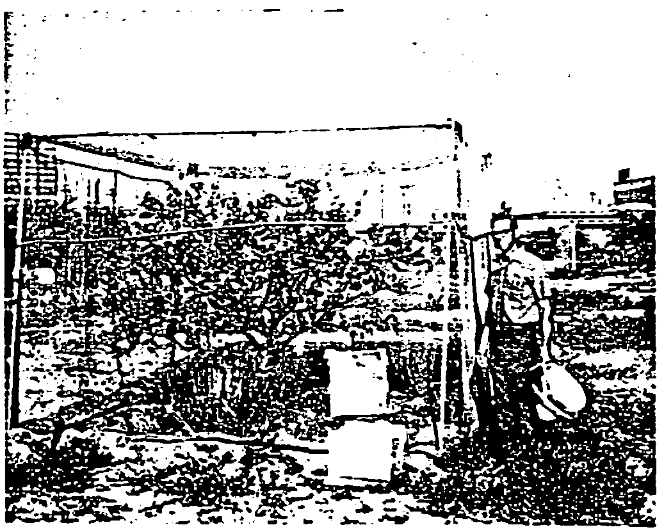

Fig. 6. Howard Morton, a herbicide specialist, is standing beside one of the cages containing a colony that was used in this study.

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